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Optimization of plasma parameters with transverse magnetic field strength and pressure to maximize H^- ion density in a negative hydrogen ion source

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Transverse magnetic filter field as well as operating pressure is considered to be an important control knob to enhance negative hydrogen production via plasma parameter optimization in the transformer coupled plasma (TCP) H^- ion source. As expected from the particle transport with the transverse filter field electron temperature in the extraction region is well controlled by increasing the field strength, but electron density near the extraction region was unexpectedly observed to be increased rather than decreased with higher field strength.[1] To clarify the unexpected electron density profile with the transvers field, axially movable Langmuir probe is installed for the profile of plasma parameters obtained from the electron energy distribution function. Increase of electron density is measured toward the maximum magnetic field position in the extraction region, which may be explained by reduced axial diffusion of low energy electrons as the magnetic field strength is increased. Noting that parallel and perpendicular electron diffusion coefficients change significantly with the magnetic field, measured electron temperatures and densities are analyzed by considering that more low energy electrons are transported across the field and accumulated near the extraction region with the increased magnetic field strength. In addition, effect of operating pressure on plasma parameters is understood from the diffusion coefficient changed with a momentum transfer frequency. Operating pressure affects the transport of each energy electron oppositely due to a different trend with pressure between parallel and perpendicular diffusion. Much higher pressure lessens the effect of magnetic filter with regard to a low energy electron accumulation. Furthermore, reduced electron temperature with an increased pressure in the heating region cause a decrease of ro-vibrationally excited hydrogen molecule density, which affects H- ion production with the lessened magnetic filter effect. Thus, values of magnetic field strength and operating pressure are optimized to maximize volume production of H^- ions by obtaining appropriate plasma parameters, and confirmed by measuring H^- ion population. To apply the magnetic filter effect on low energy electron accumulation effectively, magnetic filter position as well as strength must be considered seriously.

[1] O.Fukumasa, H.Naitou and, S.Sakiyama, Jpn. Appl. Phys. Vol.30, No.6A, June, 1991, pp. L1063-L1065